CAP-MOUNTED MONOCULAR VIDEO/AUDIO DISPLAY

CROSS-REFERENCE TO RELATED APPLICATION

This application claims benefit of priority of provisional patent application Ser. No. 60/391,772, filed on June 26, 2002 and entitled "Cap-Mounted Monocular Audio/Video Display." Application 60/391,772 is incorporated herein in its entirety by this reference.

BACKGROUND OF THE INVENTION

1. Field Of The Invention

This invention relates to portable video/audio display systems and, in particular, to a lightweight, portable video/audio display system that provides video images, free from environmental glare, to one eye at a time (either left or right) of content transmitted via a receiver within a casing mounted to headgear, such as a cap, by a spring-loaded clip.

2. Description Of The Related Art

In an age of wireless telecommunications and extreme mobility, numerous ways for viewing video content, such as pictures and data with sounds, have emerged to allow users to access media while they are away from their offices or computers, engaged in outdoor or remote activities or are simply relaxing in locations where traditional or larger displays or receivers are unavailable or impractical. These devices typically require some form of electronic display, an optical system to enhance or enable the viewing of that

display, an electronic means to receive, store and transmit content to the display for presentation, and a means for powering the device.

Two of the most common forms of such mobile viewing are portable televisions and video game players. Although these devices use battery-powered displays and have the ability to receive or store content for presentation, they are limited in their ability to deliver satisfactory video images outdoors because their displays are subject to "washout" or glare from bright sunlight or surroundings. Further, because such devices are typically hand-held, their screen sizes are small and thus "distance" the user from many of the details that would normally be seen on the display screen of a larger, less portable device.

An effective means to prevent both washout and loss of detail is to employ in portable displays a technique which has been used successfully in binoculars and camcorders. By adding a soft rubber eyecup, the optics and display can be placed in close proximity to the eye and sealed snugly so that detail can be observed through an apparent increase in screen or image size, and stray glare from the environment is minimized. However devices which adopt this method encounter new problems, among them: (a) finding ways to adjust and hold the combined eyecup/display in a comfortable yet functional position close to the eyes; and (b) permitting the user free use of both hands while in the process of viewing.

Past solutions to these problems have produced exotic and expensively designed heads-up displays or head mounted displays. Heads-up displays typically involve the presentation of video-generated images which are superimposed on top of, or into, a user's line of sight of the real world through the use of image reflection or image projection devices such as prisms and mirrors or specially coated glazings. Such displays can be free-standing, for example as a device mounted to the top of an automobile's instrument panel in the driver's line of sight; reflected onto another component in the driver's line of sight, such as the windshield; or onto an optical display panel built into a helmet or headpiece worn by the driver. Heads-up or head mounted displays, such as those worn by combat pilots, often include not only all of the display and viewing elements necessary, but also the operational components described above and a means for mounting these elements and fitting the assembly comfortably to the head of a potential user. Such devices are referred to as "head mounted displays" or "HMDs." As much design and manufacturing effort typically has gone into the "head mount" portion of HMDs as into the "display" portion.

Helmet styles

Early binocular and monocular HMDs were developed for combat troops and aircraft applications such as targeting and night vision. Typically, these HMDs were incorporated into hard shell helmets which were large, heavy and cumbersome, with the combined HMD-helmet unit highly integrated. Additionally, helmets are now being used for "immersive experiences" such as virtual reality, with some providing 3-D visuals and wrap-around sound.

Mask styles

"Mask" styles, as do helmets, integrate the functional elements of a display system, i.e., the optics, the display, the electronics drivers, and the receiver(s) or storage device(s) -- into a simpler form of helmet or into an elaborate, fully adjustable face mask or headband. Such masks or headbands must be designed to accommodate a wide range of head shapes and sizes, and a broad range of price points and consumer profiles, most of which are today both high-end and upscale. For such products, as much development and investment typically goes into the "mount" as it does the "display." The HMD products marketed have varied widely in consumer acceptance. Some potential users have found themselves uncomfortable, intimidated, embarrassed or simply "turned off" by the idea of having to wear an elaborate piece of head gear simply to watch a video image portably. Past efforts at creating mask style HMDs often have resulted in devices that make their users feel quite self-conscious and perceiving themselves as looking like a robot, an alien, a nerd, a show-off, a fool or an idiot. For this reason, and because they are also expensive, mask style HMDs have not been popular in the marketplace.

Eyeglass styles

Efforts to make HMDs "blend-in" or to become more acceptable to consumers have resulted in combinations of optics and displays that are integrated into what appear to be common eyeglasses. Such attempts have resulted in bulky or cumbersome frames, thick or costly lenses or expensive components due to the need for miniaturization. Often these configurations require the remote placement of systems or components such as batteries in

order to preserve and simulate eyeglass styles acceptable to consumers. Even so, because many people object to wearing expensive glasses of any kind, eyeglass styles have achieved only marginal success.

U.S. Pat. Nos. 5,815,126 and 6,452,572 B1 to J.C.C. Fan et al. disclose a monocular portable system that includes a matrix display mounted within a housing positioned relative to one eye. The display is connected to a video or other information source providing images or data. A supporting harness holds the display on the user's head. In one embodiment the display is mounted to an arm adjustably extendable from the harness so the display can be moved laterally in and out of the eye's field-of-view or from one eye to the other without adjusting the harness. In another embodiment the display is pivotable vertically so that the user can move it upwards out of the field-of-view.

U.S. Pat. No. 5,471,678 to A. Dor discloses a flip-up mount for a night vision system which can be either a monocular or binocular device. The mount includes a pivotal armature attached to a carriage which engages a coupling on the night vision system. The armature pivots between a position enabling an operator to use the system, and a tilt-up stowed position.

U.S. Pat. No. 5,003,300 to B.A. Wells discloses a head mounted, monocular display for video imagery. A virtual raster display unit is attached to the user's head by a U-shaped harness which grips the sides and back of the head, or is attached to a conventional helmet or to the user's eyeglasses. The

display unit can be positioned by a support member pivotally attached to the harness or helmet either in an eye's field-of-view or in a tilt-up stowed position.

U.S. Pat. No. 5,642,221 to R.E. Fischer et al. discloses a head mounted binocular display system for viewing video or other imagery. A display unit is supported by a headband with three independent adjustments: a pivot adjustment proximate to the ears; a pivot adjustment proximate to the eyes; and an adjustment which permits the unit to be displaced fore and aft from the wearer's head to permit convenient use with eyeglasses.

OBJECTIVES AND ADVANTAGES OF THE INVENTION

The objectives of the present invention are threefold: (a) create a simple, lightweight, truly affordable and efficient HMD; (b) remove physical discomforts and psychological stigma associated with wearing a strange-looking HMD in public; and (c) eliminate the necessity of researching, designing, manufacturing, distributing, servicing and providing warranties for an independent mount system solely for the purpose of supporting the display system. The system of the present invention integrates the optics, the display, and the electronics drivers, receivers and/or storage devices into a compact package to be worn on the head, but with a mounting system that incorporates caps, hats or other headgear that may be conventional or novel.

Commonly worn apparel

The baseball cap, (and similar apparel) have emerged as fashion statements unto themselves. For example, such caps carry the names, colors

and logos of countless sports teams, clubs, schools, universities, institutions, corporate entities, film and rock stars, fictional characters, themed entertainment venues, movie titles, product promotions, military forces, law enforcement, governmental bodies and political causes; the list is truly endless. Ball caps are worn by men and women, young and old, children and adults, in all weather, day or night, frontwards, backwards or sideways, are available everywhere and accepted worldwide. Although the display system of the present invention can be fitted to other types of apparel, such as a headband with a visor, the baseball cap is the most preferred headgear for use with the system of the present invention. Some of the advantages of the system of the present invention, when used with a baseball cap, are as follows:

1. By clamping a display system of the present invention to the visor of a baseball cap the need to design, make, sell or service a fully adjustable companion head-mounting system to fit all ergonomic percentiles and HMD user profiles is eliminated.

2. By clamping a display system of the present invention to the visor of a baseball cap a user is always assured of the availability of a clean, comfortable, undamaged mounting system wherever he might travel worldwide.

3. By clamping a display system of the present invention to the visor of a baseball cap a user can eliminate the stigma of wearing a foreign, odd-looking, peculiar or embarrassing piece of equipment in public surroundings.

4. Conversely, by clamping a display system of the present invention onto the visor of a favorite ball cap a user can make a fashion statement and/or continue to express his individuality and, indeed, can "personalize" the HMD should he desire to do so.

5. By clamping a display system of the present invention to the visor of a baseball cap the HMD manufacturer or retailer can attract or participate in marketing promotions with numerous companies, teams, organizations, institutions or entities which can stimulate further sales and use of the invention.

6. By clamping a display system of the present invention to the visor of a baseball cap a user can easily remove the HMD for storage or safekeeping.

7. By clamping a display system of the present invention to the visor of a baseball cap a user can easily transfer the HMD to another ballcap or to another article of clothing without damage to either the HMD or the clothing.

8. By clamping a display system of the present invention to the visor of a baseball cap a user can easily adjust the HMD laterally to accommodate for wide or narrow eye spacing, an adjustment that might otherwise be difficult or require more complex mechanisms to accomplish.

9. By clamping a display system of the present invention to the visor of a baseball cap the invention may be slid forward or aft to accommodate unique headforms or allow conventional eyeglasses to be worn.

10. By clamping a display system of the present invention to the visor of a baseball cap the electronics and display portion of the invention is protected from solar infrared and ultraviolet radiation, and shielded from cold, heat, rain, snow and other elements which might otherwise require more elaborate casing or insulation.

11. By clamping a display system of the present invention to the visor of a baseball cap a user can quickly and easily remove the HMD in the event of an emergency, upon entry into a vehicle or similar circumstance, or quickly share the HMD with another person.

12. By clamping a display system of the present invention to the visor of a baseball cap a user of the invention can rotate the HMD to the side, or alternatively 180° to the rear, to quickly restore his full field-of-view, or store the HMD (in a rearward position) while it remains on his head.

13. By clamping a display system of the present invention to the visor of a baseball cap the HMD can be carried in the 180° rearward (stored) position where it cannot be damaged or cause damage to a user should he fall or collide

with a person or inert object. Such placement or storage is generally not feasible or practical with other types of HMDs.

14. By clamping a display system of the present invention to the visor of a baseball cap a user can raise the visor of the cap upwards to quickly provide an unobstructed full field-of-view in the event of an emergency. Such movements are not always possible or practical with other types of HMDs.

15. By clamping a display system of the present invention to the visor of a baseball cap the HMD contributes to the structural integrity of the baseball cap and thus facilitates easy adjustment of the cap to various headforms, ergonomic profiles and positions.

16. By clamping a display system of the present invention to the visor of a baseball cap a user can monitor a visual display with one eye and his immediate surroundings with the other eye, or he can superimpose each of these views simultaneously or alternatively.

17. By clamping a display system of the present invention to the visor of a baseball cap a user can free both hands for use in other tasks.

PREFERRED APPLICATIONS FOR THE INVENTION

- As an HMD for operating Video Radio Control ("VRC") toys, Remotely Operated Vehicles ("ROVs"), Remotely Piloted Vehicles ("RPVs")

or for use onboard Unmanned Combat Air Vehicles ("UCAVs") equipped with wireless video and telecommunications.

- As a monocular see-through display in which computer graphics are superimposed over a user's view of the world. Such systems preferably use a prism or mirror to reflect images from a liquid crystal display (LCD) into the user's line-of-sight while still allowing light to pass through to his eyes.

- As a binocular see-through display in which computer graphics are superimposed over a user's view of the world using stereoscopic prisms to reflect images from a pair of LCDs into the user's line-of-sight while still allowing light to pass through to his eyes.

- As a remote viewfinder for camcorders, security systems, educational systems or other forms of electronic imaging.

- As a means of providing access to video manuals or inventory spread sheets to field workers, repair technicians or medical personnel who need to have both hands free to work.

- As an adjunct to gaming systems and devices in which sensors and targets keep track of position and orientation of a user's head to ensure that graphics introduced through related audio/video content systems appear in the correct places relative to the user's movements.

- As a component of eye-tracking and aiming devices in which virtual reality type position sensors are used to detect head orientation and eye movements.

- As an electronic night vision display when using a monochromatic video camera coupled to an infrared illumination source.

- As a portable TV or video gaming device.

- All, or combinations of the above for use in rugged, remote, hostile or emergency environments where larger forms of headgear (such as helmets) are either unnecessary or unavailable.

SUMMARY OF THE INVENTION

These and other objectives, advantages and applications are achieved by the present invention which in one aspect provides a monocular display system, mounted to a headgear portion, which includes: a casing; a mounting device attached to the casing detachably affixing the casing to the headgear portion and maintaining the casing aligned with and substantially parallel to the headgear portion; an arm attached to the casing and pivotable about a first axis orthogonal to the casing; and an optics assembly having an end attached to a housing, containing a display assembly, attached to the arm and pivotable about a second axis orthogonal to the casing and parallel to the first axis.

In another aspect the invention provides a monocular display system, mounted to a headgear portion, which includes a primary casing having upper and lower portions interfacing at a mating flange determining a reference plane, and a spring mounting clip attached to the casing upper portion used to detachably affix the casing to the headgear portion. The display system further includes an adjustment arm having two portions determining upper and lower flanges. The upper flange is pivotally attached to the casing lower portion, the arm and flanges are parallel to the reference plane, and the arm is pivotable at the upper flange about a first axis orthogonal to the reference plane. The display system further includes an optics assembly having a focus mechanism assembly whose first end is connected to an eyecup and whose second end is attached to a housing containing a display and backlight assembly. The housing is attached to a gimbal which is attached to the lower flange and is pivotable about a second axis orthogonal to the reference plane and parallel to the first axis.

In still another aspect the invention provides a monocular display system mounted to a baseball-type cap visor. The display system includes a primary casing having upper and lower portions interfacing at a mating flange determining a reference plane. The casing upper portion is contoured so as to shape and support the underside of the visor, and the casing lower portion has therethrough a generally circular hole. The display system further includes a spring mounting clip attached to the casing upper portion which detachably

affixes the casing to the visor. The display system further includes an adjustment arm having two portions determining upper and lower mating flanges. The upper flange is pivotally attached to the casing lower portion. The arm and flanges are parallel to the reference plane, and the arm is pivotable at the upper flange about a first axis orthogonal to the reference plane. The display system further includes an optics assembly having a focus mechanism assembly connected at one end to an eyecup, and attached at its other end to a display housing containing a display and backlight assembly. The housing is attached to a gimbal attached to the lower flange which is pivotable about a second axis orthogonal to the reference plane and parallel to the first axis.

A more complete understanding of the present invention and other aspects and advantages thereof will be gained from a consideration of the following description of the preferred embodiment in conjunction with the accompanying drawing figures provided herein. In the figures and description, numerals indicate the various features of the invention, like numerals referring to like features throughout both the drawings and description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of a primary casing and spring mounting clip for a preferred embodiment of a cap-mounted monocular video/audio display system according to the present invention.

FIG. 2 is a cross-section of the **FIG. 1** primary casing taken along the lines **2-2**.

FIG. 3 is an exploded perspective view of an optics assembly of the **FIG. 1** embodiment including a gimbaled housing containing a display and backlight assembly, an optical train of focusing and viewing lenses, and an eyecup.

FIG. 4A schematically shows a top plan view of the **FIG. 1** casing mounted to a cap visor, with the **FIG. 3** optics assembly mounted to the casing by a pivotable adjustment arm.

FIG. 4B schematically shows a front view of the **FIG. 1** casing, **FIG. 3** optics assembly, and **FIG. 4A** adjustment arm.

FIG. 5 is a cross-section of the **FIG. 4A** adjustment arm taken along the lines **5-5**.

FIG. 6 schematically shows a side view of the **FIGs. 4A** and **4B** casing and optics assembly.

FIG. 7 is a perspective view of a preferred embodiment circuit board configuration having a ribbon cable management system attached to the display and backlight assembly.

FIG. 8 schematically shows a top plan view of the **FIGs. 4A, 4B** adjustment arm and the **FIG. 7** ribbon cable management system pivoted from a first to a second position of rotation.

FIG. 9 is a top-level exploded perspective view of the display system detachably affixed to the **FIGs. 4A, 4B** cap visor, showing the **FIG. 1** casing and spring mounting clip, the **FIG. 3** optics assembly, an audio output cable, a battery pack, a clip for attaching the cable to the visor, and an earphone.

FIG. 9A is a detail perspective view of the **FIG. 9** cable clip.

FIG. 10 is a block diagram of a preferred embodiment of the video/audio electronics configuration of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As used herein, the term "detachably affixed" means that an element of the embodiment (e.g., the primary casing) can be conveniently and repetitively affixed to and detached from a headgear portion (e.g., a cap visor) without any specialized adaptor(s), tool(s), adhesive(s) or user skill(s). The term "attached" means that the elements referred to are permanently joined or at least not easily

separable. The term "connected" means that the elements referred to are easily separable.

In all preferred embodiments of the present invention, the HMD display system includes a primary casing, a pivotable adjustment arm, and an optics assembly combining a display and backlight assembly (or a display only assembly) mounted in a housing, a plurality of viewing lenses, and an eyecup, which collectively form the housing and operating structures of the HMD. These structures also serve to mount the HMD's internal mechanical and electronic operating components. Constructed preferably of conventional plastics, the HMD's primary casing incorporates conventional bearing surfaces, attachment points, bosses, internal seals and coloration to provide an attractive, articulated, protective shell for the electronic circuit boards, optics and wiring and serves as a platform for the adjustment arm. The primary casing structure preferably includes two injection-molded plastic shells, that when joined conform to, shape and reinforce the visor of a standard baseball cap, provide a surface against which the HMD will secure itself against the baseball cap's visor, and provide for attachment to the HMD's clamping mechanism. An assembly of adjustable, telescoping focus rings hold the viewing lenses the correct distance from a user's eye and, in that position, provide for gradual movement of the lenses along the optic axis to assure proper focus at the image plane. A soft rubber eyecup which prevents unwanted light from entering the viewing lenses, is connected to a lens retainer bezel. The preferred configuration for the cap-mounted HMD is monocular, with the optics assembly

and adjustment arm adapted to accommodate either eye, one at a time. In this way, while one eye is viewing an image presented on the display, the other can monitor an unobstructed view of the user's surroundings. Alternatively, either eye can be selectively closed to produce an exclusive view for the selected eye.

In accordance with the principles of the present invention the display system is preferably secured to the visor of a standard baseball cap. Alternatively, the display system could be attached in similar fashion under the brims, bills or visors of numerous types of hats, caps, helmets or other headgear. In the preferred embodiment described in detail herein, a pre-tensioned, spring-loaded, stainless steel wire clamp opens sufficiently to allow the primary casing to slip non-destructively beneath the cap's visor with the spring clamp above pinching the visor between. In so doing, sufficient clamping force is exerted to hold the display system securely in place, yet allow for its periodic adjustment either laterally, or forward and aft to accommodate various facial ergonomics and/or head sizes, with or without eye glasses. The spring-loaded clamp permits single-handed, slide-on/slide-off removal, transfer and re-installation of the display system, i.e., removable attachment. The clamp also permits the display system to be detachably affixed to other types of headgear such as a hat with a brim.

A preferred embodiment of the optics assembly includes a lens and focus mechanism, and a video display panel and backlight. Also in accordance with the principles of the present invention, a printed circuit board containing a

radio frequency ("RF") video/audio receiver and antenna array with its connection to the electronics driver circuitry for the video display is incorporated within the primary casing. Most preferably, the antenna of the present invention is of a "conformal" type. This most preferred antenna is contained entirely within the primary casing rather than placed externally where it could become damaged, hook on clothing, or interfere with a user's surroundings or with ease of operation. Powered through either internal batteries or an external, portable power pack and with content supplied through its on-board video/audio receiver or an externally connected content storage/delivery device, the display places a black and white or color video image at the image plane to be resolved using the optics assembly described herein.

Referring to **FIGs. 1** and **2**, in a preferred embodiment according to the present invention a display system **10** includes a primary casing **1** having upper and lower portions **1U**, **1L**, respectively, and a spring mounting clip **2** which collectively comprise structures for mounting the display system **10** to various types of caps and other headgear. Casing lower portion **1L** incorporates a bearing surface and retaining flange for mounting a pivotable adjustment arm **6** (shown in detailed cross-section in **FIG. 5**). Casing upper portion **1U** is contoured in two directions, as shown by cross-section **5** and contour **5A**. These contours function to support and shape the underside of a typical baseball cap visor and may be modified to accommodate different cap styles. The upper surface **7** of portion **1U** may be textured or coated to further enable gripping of

a visor underside or hat brim, or other apparel if desired or necessary. For example, surface **7** may incorporate an injection molded texture; alternatively, elastomeric coatings could be spray applied. However, such texturing or coating is not preferred in the embodiment described in detail herein. As shown in **FIG. 1**, casing portion **1L** has a cross-section **21**. As shown in **FIG. 2**, casing portions **1U** and **1L** are configured to interface snugly against each other at a mating flange **8** determining a reference plane, to seal and protect the components inside. Recesses **14A, 14B, 14C** and **14D** provide bores through which screws may be used to attach casing portion **1U** to casing portion **1L**. As further shown in **FIG. 2**, the rearward edge of casing **1** incorporates a channel **9** into which an audio microphone and power cord **110** (see **FIG. 9**) and/or a media input cable is secured and protected. Channel **9** includes an arcuate upper portion **9A** attached to or formed integrally with casing portion **1U**, and an arcuate lower portion **9B** attached to or formed integrally with casing portion **1L**. Although molded from high-impact polycarbonate plastic, channel portions **9A** and **9B** allow for press-in insertion or tension removal of cord **110**. Casing portions **1U** and **1L** include molded-in positioning shoulders **11A, 11B** for centering and securing an electronics printed circuit board (see **FIG. 7**). Two spring clip mounting channels **12A, 12B** are molded into the interior surface of casing portion **1L**. Corresponding channels are molded into the interior surface of casing portion **1U**, but are not shown in **FIG. 1**. The mounting channels secure the spring mounting clip **2** to casing **1**. In one preferred embodiment, vent holes placed at various locations in the primary casing allow cooling

airflow to the electronics within the casing. Such vents, for example, could be included along the casing rearward edge.

Polycarbonate (sometimes referred to by its trade name LEXAN™ and manufactured by General Electric Corporation) is the preferred material for the casing components shown in **FIGs. 1** and **2** due to this plastic's inherent strength, impact resistance, engineering qualities, coloration availability and resistance to moisture.

Referring to **FIGs. 1** and **5**, casing lower portion **1L** further includes a generally circular hole **4** therethrough concentric with a generally vertical axis **20** and sized to accommodate a ribbon cable management system **170** (see **FIGs. 7, 8**). Hole **4** is transected by cross-section **21** which terminates in an annular hook-shaped end portion having upper and lower surfaces **21U, 21L**, respectively. The arm **6** has first and second portions **16** and **18**, respectively, determining when interlocked generally circular upper and lower mating flanges **22U, 22L**, respectively. Assembly of arm **6** is accomplished by sliding portions **16** and **18** in opposite directions, as shown by opposed arrows **19**, until flanges **22U** and **22L** are snug, and simultaneously clamping about cross-section **21**, at **20A**, and gimbal **26**, at **20B**, thereby forming generally circular upper and lower bearing surfaces **21U, 21L**, respectively, so that arm **6** is pivotable about vertical axis **20** and can be rotated from one position to another.

Referring to **FIGs. 3** and **5**, an optics assembly **3** includes a gimbal **26** attached to a generally spherical display housing **28**. Gimbal **26** includes a top flange **20B**. Optics assembly **3** further includes a commercially available focus mechanism assembly **40** including telescoping focus rings **40A** and **40B**, a manually adjustable focus ring **40C**, and a lens retainer bezel **40D**. Plastic lens elements **42** and **44** are conventionally snap-inserted into bezel **40D**. A soft rubber eyecup **50** connects to bezel **40D** at the viewing end of assembly **3**. Display housing **28** includes upper and lower hemispheres **28A**, **28B**, respectively, conventionally joined through mechanical fasteners (not shown). Assembly is accomplished by joining hemispheres **28A** and **28B** around molded-in spindles **31** in each side of gimbal **26**. Elastomer "O" rings **29** inserted over spindles **31** prior to assembly produce a desired friction to hold the display housing **28** in position on gimbal **26** once it has been adjusted so that eyecup **50** fits a user's eye, and assure continued flexibility and ease of adjustment. Display housing **28** incorporates internal bosses molded-in to hemispheres **28A** and **28B** to accept a commercially available display and backlight assembly **180** (see **FIG. 7**). Alternatively, the backlight is omitted so that housing **28** contains a display assembly rather than a display and backlight assembly. Eyecup **50** can be rotated about optic axis **66** for user comfort and to prevent unwanted light from reaching the display. If eyecup **50** is of an asymmetric design, it can be rotated 180° about axis **66** to better seal against the eye on the opposite side of the user's face.

FIGs. 4A and **4B** schematically illustrate the display system **10** detachably affixed to a standard baseball cap **80**. Thus, by definition, the display system becomes an HMD. The primary casing **1**, adjustment arm **6** and optical assembly **3** are shown in their proper relationship to each other. **FIGs. 4A**, **4B** and **9** further show the HMD to be detachably affixed to visor **82** of cap **80**. The **FIG. 9** exploded perspective view shows the HMD as it would appear just prior to attachment to the visor, or just after removal. The HMD is secured to the visor by clamping pressure applied by spring mounting clip **2** against the upper surface **7** of primary casing **1** at points **2A** and **2B** (see **FIG. 1**). The HMD is slid onto the cap visor by slightly separating spring clamp **2** from surface **7** and then sliding the HMD in a rearwards direction as indicated by arrow **86R** in **FIG. 9**. The HMD is removed simply by sliding it forward off the end of the cap visor. Although the optics assembly **3** is highly adjustable through rotation about axes **30** and **66** and rotation with respect to gimbal **26**, additional adjustment is possible by sliding the entire HMD left or right against the surface of the visor as indicated by arrows **88L**, **88R**. Moreover, as indicated by indicia **89R**, **89P**, other adjustments are possible by rotating the cap clockwise or counterclockwise about axis **89Z** and/or adjusting the visor's pitch (i.e., rake) about axis **89Y**, respectively. As shown in **FIGs. 9** and **9A**, a clip **74** secures the cord **110** and an earpiece **112** to the lower edge of cap **80** where desired.

Rotation of adjustment arm **6** around vertical axis **20** and rotation of optics assembly **3** around vertical axis **30** allow eyecup **50** to be aligned with a

user's right or left eye, and/or to be spaced forward or aft for user comfort or to accommodate the wearing of standard eyeglasses. Movement of the display housing **28** about axis **30** and rotation of the eyecup **50** about axis **66** allows the eyecup to be adjusted in order to arrive at an orientation most comfortable to the user. Because wiring and electrical connections are routed from the primary casing **1** through arm **6** into optics assembly **3**, stops are incorporated in flanges **4A** and **20B** to prevent rotations greater than 350°, thus assuring there will be no damage to the HMD's internal electronic connections.

Pivotal movement of the adjustment arm **6** and optics assembly **3** is further illustrated in **FIGs. 4A** and **4B**. Repositioning for the left or right eye is accomplished by pivoting arm **6** about axis **20**, as indicated in **FIG. 4A** by arrow **92**, in an adjustment for the right eye. Still referring to **FIG. 4A**, such adjustments generally require pivoting arm **6** about axis **20** in a clockwise direction, then pivoting optics assembly **3** about vertical axis **30** in a counterclockwise direction, and making a final vertical adjustment as indicated in **FIG. 6** by arrows **94**. By terminating the pivotal rotations about axes **20** and **30** at a point of comfort for the user, wherein the eyecup is aligned to the user's eye or against the surface of eyeglasses should the user be wearing them, then with the eyecup aligned vertically by adjusting the optic axis **66** upwards or downwards as shown by the arrows **94**, the image from the display and backlight assembly **180** can be precisely centered within the eyecup for all of the human percentiles in the target user market, from child through adult. In the **FIG. 4A** view looking down, the optics assembly **3** shown at **90** is positioned so

eyecup **50** is adjusted for the user's left eye. In the **FIG. 4B** view looking rearward, the optics assembly **3** shown at **92** is positioned so eyecup **50** is adjusted for the user's right eye. To accommodate various user cap position preferences, it is further possible to adjust the eyecup's horizontal optic axis as shown at **94** of **FIG. 6**, by rotating gimbal **26** about axis **30**. Alternatively, it is possible to eliminate this additional angle adjustment since it is possible for some users to achieve positioning comfort by moving the cap itself. There are also alternative configurations and alternate pivot positions for achieving the full range of adjustments that may be desired by users, such as incorporating a ball swivel joint at the upper center of display housing **28** at flange **20B**, or at the point **20A** (see **FIG. 5**) where arm **6** is attached to the bottom of casing **1**. It is further a preferred embodiment of the present invention to make arm **6** of a flexible material which would be able to torque about its lateral axis **95** (see **FIG. 4A**) to thereby provide the necessary vertical eyecup adjustment.

FIGs. 4A and **4B** show schematically how, in a typical baseball cap, increasing the lateral curvature of the visor will reduce the diameter of the headband, which can be helpful in accommodating smaller head sizes or proportions. This can occur when the cap is placed on a smaller head and/or the visor is manually recontoured to a greater curvature. Such changes generally occur along a conical axis in the forward quarters of the cap about the cap's plan view center (as indicated at **98** of **FIG. 4A**), and resolve themselves near the left and right edges of the visor (as indicated at **99** of **FIG. 4B**). For this reason, upper surface **7** and lateral contour **5A** of casing **1** (see **FIG. 1**) are

preferably contoured within a range of curvatures sufficient to maintain apparel flexibility and traditional comfort adjustments inherent to a baseball cap. Specifically, upper surface **7** at contour **5A** is most preferably formed with a circular arc whose center lies in a plane generally orthogonal to bottom surface **1S** of casing portion **1L** and whose transverse radius is in a range from 3.9 inches to 4.2 inches (as shown by radius **100** in **FIG. 4B**). To further permit flexibility the overall width of casing **1** should be held, preferably, to approximately 4.0 inches (as shown at **102** of **FIG. 4A**) with a forward and aft depth of approximately 2.30 inches (as shown at **104**). Similarly, the spring mounting clip **2** should be held, preferably, to approximately 3.15 inches in lateral width (as shown at **106**) and approximately 2.40 inches in depth (as shown at **108**). The foregoing dimensions are not absolute, but are preferred, based on the use of standard baseball caps such as those proposed in the preferred embodiment.

Referring again to **FIG. 9**, cable **110** provides audio output via wire **111** to earphone **112** positioned in the desired ear, while clip **74** attaches cable **110** to the desired side of the cap **80**. Cable **110** also delivers battery power to the HMD from a battery pack **350** which can be carried in the user's pocket, clipped to the user's belt or, if sufficiently small and light, be incorporated into casing **1**. Power is controlled at the battery pack by switch **124**. As shown in **FIG. 9A**, clip **74** preferably includes a conventional, quick-release lever **74L** for easy removal of either the cap or the battery pack. Also, clip **74** may include an input jack so that video and/or audio from an external device can be

easily connected to enable delivery of video and/or audio to the HMD. A similar input jack can also be added to primary casing **1** for this purpose. In another preferred embodiment, casing **1** may include RCA type video/audio output jacks so that video/audio transmissions received via an internal antenna and receiver system can be processed and output to a conventional video monitor or television set. **FIG. 10** is a block diagram showing the interface of other electronics such as a video camera with the display and backlight assembly **180**.

FIG. 7 is a perspective view of a preferred circuit board configuration **160** shown with its ribbon cable management system **170** having a ribbon "interconnect" cable **250** attached to the display and backlight assembly **180**. Ribbon cable, which is thin and flexible, has printed circuitry on its surface to carry electrical signals, and is commonly known as "flex-circuit interconnect cable." Such cables are made by Minco Products, 7300 Commerce Lane, Minneapolis, MN 55432. The Kopin AMLCD CyberDisplay 320 described below and preferred for use in the display and backlight assembly **180** presently requires an interconnect cable with twenty wires, and four additional wires for the backlight. Maintaining this connectivity through adjustment arm **6**, which must pass electronics wiring through hollow centers spaced approximately 1.6 inches apart and which further pivots about those centers more than 180° and which can turn 90° at both ends, requires both an interconnect cable fitting easily inside arm **6** and a pivot mechanism. Cable management system **170** includes a loop **250L** of ribbon cable which rolls and unrolls as the interconnect

cable **250** pivots within arm **6** and about axes **20** and **30**. The size of the loop is dictated by the minimum bend radius of the flex-circuit material available; the ribbon material can bend freely in only one plane.

FIGs. 7 and **8** illustrate structures that function to coil and uncoil the 20-wire interconnect **250** as it pivots around parallel axes **20** and **30** and maintains a plane essentially perpendicular to the axes of rotation. Rotation about axes **20** and **30** each allow for rotations in excess of 180°. **FIG. 7** shows an antenna **300** attached to circuit board **150**. Board **150** includes superposed upper and lower sockets **152U**, **152L**, respectively, proximate to a generally circular hole **150H** whose center coincides with axis **20**. Socket **152U** accepts an imager connector **154** (see **FIG. 5**), and socket **152L** accepts a backlight connector **153**. Interconnect cable **250** passes through hole **150H** around pivot axis **20** where it turns 90° and forms the loop **250L** which grows or shrinks as arm **6** rotates; in so doing, it retains a natural curve that is within the design limitations of the printed circuit ribbon material. In **FIG. 7**, a hub-like region **252** at axis **20** (seen also in **FIGs. 5** and **8**), around which loop **250L** is constrained to curve, is depicted as a dashed cylinder. As the parts rotate, the interconnect cable **250** at **262** and **282** turns 90° to lie flat inside arm **6**, guided by surfaces **260A** and **260B** (see **FIG. 8**). In **FIG. 7**, a hub-like region **280** at axis **30**, around which loops **262** and **282** are constrained to curve, similarly is depicted as a dashed cylinder. **FIG. 8** shows a typical pivot diagram for the cable management system **170** in preferred embodiments of the present invention. In this view, which is perpendicular to the axes of rotation **20**, **30**, two ribbon cables, the

display interconnect **250** and the backlight circuit interconnect **255**, enter adjustment arm **6** through two curved walls **260A** and **260B** which serve to constrain the loops of ribbon material **262, 282** to acceptable shapes. When arm **6** is moved clockwise (indicated by arrow **270**) around the region **280** (see **FIG. 5**) the loops grow in size. When the arm is moved counterclockwise (indicated by arrow **275**) the loops shrinks. Several ribbon cables or combinations of ribbon cable and flexible wiring can be accommodated as long as sufficient space **284** is left between the concentric loops to allow for their differing circumferences caused by differing radial distances from the axis of rotation. Imager circuit **250A** and backlight circuit **250B** exit along the surface of arm **6**. Mechanical stops are incorporated into polycarbonate bearing surfaces between arm portions **16**, **18** and flange **4A** of casing **1** (see **FIG. 5** at **20A**) using conventional practice, and also between portions **16, 18** and gimbal **26 (see FIG. 3** at **20B**) to prevent rotation beyond the design range of the mechanism. The ribbon cable management system **170** can be designed for attachment to either side of the articulated mechanisms, viz., the arm portions **16, 18** or the casing **1** and gimbal **26**.

Display system **10** preferably utilizes a Kopin active-matrix liquid crystal display (AMLCD) CyberDisplay 320, shown at **200**, available in either monochrome or color, manufactured and distributed by Kopin Corporation, 695 Myles Standish Boulevard, Taunton, MA 02780. The CyberDisplay 320, which uses a solid state LED as its light source, has 320 x 240 spatial resolution, and optionally uses a high efficiency backlight **210** designed to meet the low power

and ruggedness requirements needed for portable applications. Backlight **210** snaps onto the rear of the display unit **200** to form the display and backlight assembly **180**. The CyberDisplay 320 provides excellent eye relief allowing it to be positioned approximately three inches from the eye for comfortable viewing, has a rugged polycarbonate housing, and is of ultra-compact size having an active display area of only 4.8 mm x 3.6 mm, or only 0.24 inches diagonally. Despite this small size, the virtual image seen by a user is comparable to viewing a 20-inch diagonal display from a distance of five feet. Kopin Corporation also manufactures an optical system suitable for use as focus mechanism assembly **40.** Motorola Corporation also offers a solid state backlight suitable for use in preferred embodiments of the present invention. Clearly it is advantageous for a monocular viewing device to be adjustable for use by either the left or right eye. This can be accomplished by plugging an eyepiece into either a left or right receptacle, sliding a mechanism sideways along a track run, or pivoting a centrally mounted arm into a position suitable for viewing by either eye. Pivoting has been selected for the preferred embodiments because a pivoting mechanism is more durable and simpler to fabricate than a tracked mechanism, and does not entail problems due to disconnected, lost, damaged or contaminated piece-parts. However, embodiments of the cap-mounted monocular display system described herein could employ a tracked or modular mechanism or a variation of the pivoting mechanism described herein and still be adaptable to commonly available headgear and apparel.

FIG. 10 shows a block diagram for a wireless radio frequency video/audio receiver which is part of display system **10** and other preferred embodiments of the present invention. Such miniaturized receivers are quite common now and are commercially available from numerous manufacturers. RF video/audio transmitters and receivers such as the **FIG. 10** receiver may be utilized legally in the UHF or VHF bands by licensed users, or in any of the unlicensed bands at 900 MHz, 2.4 GHz or 5.7 GHz. Other transmission modes such as infrared laser or acoustic waves also could be effectively used in specific applications. **FIG. 10** further includes a block diagram of electronics for the key components of the optics assembly **3** including the focus mechanism assembly **40**, display unit **200**, and backlight **180** available commercially from Kopin Corporation, and for a display signal decoder and LCD driver. Design of the circuitry and related components of the the RF and display systems will always be based upon current and rapidly emerging developments in RF transmission, power and display technologies, component miniaturization, integration, end user features and "price points" (ultimate product cost targets) and therefore will be reconfigured periodically on a continuing basis. The electronics section of the display system **10** is designed to receive wireless, radio frequency transmissions for video, audio and data from remote locations, or alternatively to interface directly with other types of devices which receive, store, process and/or deliver video/audio content. These techniques may be used separately or together to receive, process and distribute content for presentation by the display unit **200**. Although **FIG. 10** depicts a basic 2.4 GHz video/audio receiver and display-related circuitry, it should be noted that many

different types of receiver systems can be employed to accommodate various needs and specific applications. Further, a complete radio-control transmitter system can optionally be added to the basic electronics package so that user(s) can operate remotely-controlled, video-guided vehicles and/or devices while they simultaneously monitor and respond to constantly changing images which are being captured and returned via wireless video/audio transmissions from the vehicles and/or devices. It is also possible to connect external video graphics generators, computers, cameras, night vision sensors, video or data storage devices, and other types of equipment to the display system **10** through an umbilical, to allow such equipment to use the display unit **200** or permit the use of external audio equipment. Display system **10** can be adapted to incorporate a solid state miniature video camera, integrated either as part of the casing **1** or optics assembly **3**. Such miniature cameras and wireless transmitters and receivers are manufactured, distributed and retailed by companies such as: X-10, of Seattle, WA; Supercircuits of Liberty Hills, TX; and Marshall Industries of Torrance, CA.

The **FIG. 10** block diagram illustrates a preferred internal electronics configuration using a conventional 2.4 GHz video/audio receiver mounted on circuit board **150**. This receiver, which is available from RadioShack Corporation, 100 Throckmorton Street, Ft. Worth, TX 76102, as its 2.4 GHz wireless observation kit (CW6601), is conventionally used for video-guided toys and remotely-directed video cameras. In the receiver portion of **FIG. 10**, video and audio are initially received at antenna **300** (shown in **FIG. 7**) which is

manufactured using a process in which the essential receiving elements are designed or etched into or printed onto a flat substrate material which can then be mounted on or just above a printed circuit board (PCB). One such antenna type is known as a fractal antenna, or "fractenna," because it uses numerous fractal triangles, etched into a surface, which ultimately become separate antennas in an antenna array. Such antennas through their jagged shapes generate electrical capacitance and inductance, thereby eliminating the need for external components to further tune the antenna or broaden the frequency range. Fractal antennas are produced by Fractal Antenna Systems Inc. of Malden, MA, among others. The antenna **300** shown in **FIG. 8**, available as the "2.4 GHz Model" is specifically shaped for 2.4 GHz transmission and reception. This antenna consumes very little space and can be mounted flat within the primary casing **1** (see **FIGs. 1** and **7**). The antenna is relatively cheap, and cannot easily be broken, dirty or tangled during usage as would ultimately occur if a conventional antenna were used..

The blocks in **FIG. 10** are more completely described as follows. Circuit board **150** includes: antenna **300**; RF filter **302**; low noise amplifier (LNA) **303**; phase locked loop (PLL) **304**; LNA **305**; demodulator **306**; signal **307**; video out **308** (connected to an audio RCA connector **312A** and a video RCA connector **312V**); audio out **309** (connected to earpiece **112**); and signal decoder and LCD driver **311** (connected to display unit **200** and backlight **210**). Battery pack **350** is connected to circuit board **150** through switch **124**. A camera module **400** includes: lens **401**; camera sensor **402**; iris control **403**;

microphone **404**; audio amplifier **405**; and a video/audio signal processor **406**. Processor **406** inputs a video/audio signal **408** via video/audio selector switch **410** from a video/audio transmitter **360** (connected to antenna **360A**) , video/audio recording and storage device **380**; or video/audio processor, special effects, enhanced vision processor or graphics generator **500**.

In another preferred embodiment, the display system of the present invention is adapted to be a portable television. This is accomplished by adding a digital TV tuner. Such tuners are available from several manufacturers of digital tuners; one of these, the Japanese company Alps Electric Co., Ltd., 1-7 Yukigaya-Otsuka-cho, Otaku, Tokyo, Japan 145-8501, manufactures the preferred tuner for this application of the present invention. The Alps tuner is a chip tuner capable of tuning in VHF channels 1 to 13 and UHF channels 14 to 69. The Alps tuner, with its supporting circuitry is contained inside the primary display system case. This tuner and its supporting circuitry would be contained inside the primary casing.

While the present invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments, but to the contrary, is intended to cover all modifications, equivalent arrangements and alternative constructions included within the spirit and scope of the invention, as set forth in the appended claims, and is to be

accorded the broadest interpretation so as to encompass all such modifications, arrangements and constructions.